Subt A2

We claim:

1. A single crystal silicon segment having two major, generally parallel surfaces, one of which is the front surface of the segment and the other of which is the back surface of the segment, a central plane between the front and back surfaces, a circumferential edge joining the front and back surfaces, a surface layer which comprises a region of the segment below the front surface and a distance, D_1, as measured from the front surface and toward the central plane, and a bulk layer which comprises a second region of the segment between the central plane and the first region, the segment being characterized in that

nonseq.

the segment has a non-uniform distribution of minority carrier recombination centers, with the concentration of the centers in the bulk layer being greater than the concentration in the surface layer and with the centers having a concentration profile in which the peak density of the centers is at or near the central plane with the concentration generally decreasing from the position of peak density in the direction of the front surface of the segment.

2. The segment of claim 1 having a carbon concentration which is less than about 1×10^{16} atoms/cm^3.

3. The segment of claim 1 having a carbon concentration which is less than about 5×10^{15} atoms/cm^3.

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4. The segment of claim 1 having a thickness ranging from about 500 microns to about 800 microns.

5. The segment of claim 1 having a thickness ranging from about 800 microns to about 1200 microns.

6. The segment of claim 1 wherein the concentration of minority carrier recombination centers in the surface layer is less than about 1×10^{11} centers/cm^2.

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7. The segment of claim 1 wherein the concentration of minority carrier recombination centers in the surface layer is less than about 1 x 10^{13} centers/cm^2.

8. The segment of claim 1 wherein the distance D_1 is at least about 10 microns.

9. The segment of claim 1 wherein the distance D_1 is at least about 30 microns.

10. The segment of claim 1 wherein the distance D_1 is at least about 50 microns.

11. The segment of claim 1 wherein the distance D_1 is at least about 100 microns.

12. The segment of claim 1 wherein the front surface is polished.

13. A single crystal silicon segment containing minority carrier recombination centers and having two major, generally parallel surfaces, one of which is the front surface of the segment and the other of which is the back surface of the segment, a central plane between the front and back surfaces, the recombination centers having a non-uniform distribution between the front and back surfaces with a maximum concentration of the recombination centers being in a region which is between the front surface and the central plane and nearer to the front surface than the central plane, the concentration of the recombination centers increasing from the front surface to the region of maximum concentration and decreasing from the region of maximum concentration to the central plane.

14. The segment of claim 13 having a carbon concentration which is less than about 1 x 10^{16} atoms/cm^3.

15. The segment of claim 13 having a carbon concentration which is less than about 5×10^{15} atoms/cm^3.

16. The segment of claim 13 having a thickness ranging from about 500 microns to about 800 microns.

17. The segment of claim 13 having a thickness ranging from about 800 microns to about 1200 microns.

18. The segment of claim 13 wherein the maximum concentration of recombination centers is within about 5 microns form the front surface of the segment.

19. The segment of claim 13 wherein the maximum concentration of recombination centers is within about 10 microns form the front surface of the segment.

20. The segment of claim 13 wherein the maximum concentration of recombination centers is within about 20 microns form the front surface of the segment.

21. The segment of claim 13 wherein the maximum concentration of recombination centers is within about 40 microns form the front surface of the segment.

22. The segment of claim 13 wherein the front surface is polished.

23. A process for heat-treating a single crystal silicon segment to influence the concentration profile of minority carrier recombination centers in the segment, the silicon segment having a front surface, a back surface, a central plane between the

front and back surfaces, a surface layer which comprises the region of the segment between the front surface and a distance, D, measured from the front surface and toward the central plane, and a bulk layer which comprises the region of the segment between the central plane and surface layer, the process comprising:

heat-treating the segment in an atmosphere to form crystal lattice vacancies in the surface and bulk layers;

controlling the cooling rate of the heat-treated segment to produce a segment having a vacancy concentration profile in which the peak density is at or near the central plane with the concentration generally decreasing in the direction of the front surface of the segment; and,

thermally diffusing platinum atoms into the silicon matrix of the cooled segment such that a platinum concentration profile results which is substantially dependant upon the vacancy concentration profile.

24. The process of claim 23 wherein said heat-treatment to form crystal lattice vacancies comprises heating the segment to a temperature in excess of about 1175 °C in a non-oxidizing atmosphere.

25. The process of claim 23 wherein said heat-treatment to form crystal lattice vacancies comprises heating the segment to a temperature in excess of about 1200 °C in a non-oxidizing atmosphere.

26. The process of claim 23 wherein said heat-treatment to form crystal lattice vacancies comprises heating the segment to a temperature in the range of about 1200 °C to about 1275 °C in a non-oxidizing atmosphere.

27. The process of claim 23 wherein said cooling rate is at least about 20 °C per second through the temperature range at which crystal lattice vacancies are relatively mobile in silicon.

28. The process of claim 23 wherein said cooling rate is at least about 50 °C per second through the temperature range at which crystal lattice vacancies are relatively mobile in silicon.

29. The process of claim 23 wherein said cooling rate is at least about 100 °C per second through the temperature range at which crystal lattice vacancies are relatively mobile in silicon.

30. The process of claim 23 wherein platinum atoms are thermally diffused into the silicon matrix of the segment by heating the segment to a temperature ranging from about 670 to about 750 °C.

31. The process of claim 23 wherein platinum atoms are thermally diffused into the silicon matrix of the segment by heating the segment form about 10 minutes to about 2 hours.

32. The process of claim 23 wherein prior to platinum in-diffusion the heat-treated or cooled segment is subjected to a second heat-treatment in an atmosphere of pure oxygen or pyrogenic steam, the temperature of said second heat-treatment being at least about equal to the temperature of the first.

33. The process of claim 23 wherein said heat-treatment to form crystal lattice vacancies comprises the steps of:

(a) subjecting the segment to a first heat-treatment at a temperature of at least about 700 °C in an oxygen containing atmosphere to form a superficial silicon dioxide layer which is capable of serving as a sink for crystal lattice vacancies; and,

(b) subjecting the product of step (a) to a second heat-treatment at a temperature of at least about 1150 °C in an atmosphere having an essential absence of oxygen to form crystal lattice vacancies in the bulk of the silicon segment.

34. A process for heat-treating a single crystal silicon segment to influence the concentration profile of minority carrier recombination centers in the segment, the silicon segment having a front surface and a back surface, the front surface having only a native oxide layer present thereon, and a central plane between the front and back surfaces, the process comprising:

heat-treating the front surface of the segment in a nitriding atmosphere to form crystal lattice vacancies in the segment;

controlling the cooling rate of the heat-treated segment to produce a vacancy concentration profile in the cooled segment in which a maximum concentration is between the front surface and the central plane and nearer to the front surface than the central plane, the vacancy concentration generally increasing from the front surface to the region of maximum concentration and generally decreasing from the region of maximum concentration to the central plane; and,

thermally diffusing platinum atoms into the silicon matrix of the cooled segment such that a platinum concentration profile results which is substantially dependant upon the vacancy concentration profile.